REPORT OF THE CHIEF OF THE BUREAU OF AGRICULTURAL CHEMISTRY AND ENGINEERING, 1942

UNITED STATES DEPARTMENT OF AGRICULTURE,
AGRICULTURAL RESEARCH ADMINISTRATION,
BUREAU OF AGRICULTURAL CHEMISTRY AND ENGINEERING,
Washington, D. C., October 12, 1942.

Hon. CLAUDE R. WICKARD,
Secretary of Agriculture.

DEAR MR. SECRETARY: I present herewith the report of the Bureau of Agricultural Chemistry and Engineering for the fiscal year ended June 30, 1942.

Sincerely yours,

C. F. SPEH, *Acting Chief.*

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During the 1942 season, work was started in Texas to determine the practicability of modifying the usual processing techniques to permit conservation by canning of substantial quantities of vegetables (usually wasted) that are left after the close of the shipping season where they are grown commercially for the fresh-vegetable markets.

PREPARING FRUITS FOR OVERSEAS SHIPMENT

Fruit products are among the important foods shipped to Great Britain under the Lend-Lease Act since they add variety to the diet and supply carbohydrates, minerals, and vitamin C. Because of the shortage of tin plate for containers and the lack of adequate refrigeration on most ships, special methods of preserving and packing are required. In a process developed for citrus fruit marmalade base, sulfur dioxide was used as a preservative and wooden barrels as shipping containers. Efforts were made to extract the maximum proportion of pectin from the oranges and grapefruit used in preparing the marmalade base to insure that it would gel when later reduced to a fruit content of 15 or 20 percent. This method of producing citrus marmalade base was used in five food processing plants in Florida, Maryland, and New Jersey. A system of factory inspection was formulated for use by the Agricultural Marketing Administration, which is supervising the processing and delivery of the product. During the past year more than 50,000,000 pounds of grapefruit and orange pulp was used for this purpose.

In experiments on the preparation of concentrated self-preserving marmalades for lend-lease shipment from noncitrus fruits, 42 lots were prepared for examination and comment. Apple pomace and dried apple chops were used to furnish the pectin base and frozen apricots, cherries, and berries of various kinds to give flavor and body. Phosphoric acid was used to promote extraction of pectin and give the proper acidity. Pertinent data were obtained regarding relative costs and quality of products prepared by different procedures.

After conferences with representatives of the British Food Mission and the Agricultural Marketing Administration regarding the kinds of concentrated juice required, experimental work was undertaken to improve the retention of flavor and vitamins in citrus juice concentrates for lend-lease shipment to Great Britain. A number of samples of concentrated grapefruit and lime juices were prepared by different methods for trial. A continuous juice concentrator which promises satisfactory products was devised.

Specifications for the preservation of strawberries and raspberries with sulfur dioxide were prepared for the Agricultural Marketing Administration for use in purchasing these fruits for lend-lease shipment. More than 11,000,000 pounds of strawberries and 1,000,000 pounds of raspberries were processed according to these specifications. It was found possible to maintain firmness of the fruit by adding the proper proportion of calcium salts, which depended on variety and degree of maturity. Satisfactory procedures for processing and packing peaches and other small fruits were developed and assistance was given to processors in the solution of difficulties encountered in the application of the chemicals specified for preservation and maintenance of firmness.

ALCOHOL FROM CITRUS-WASTE LIQUORS

Methods were demonstrated for producing ethyl alcohol from the fermentable sugar in the liquor pressed from limed citrus-cannery residues to be dried for stock feed, and for recovering feed yeast from the spent liquor. A survey of the quantity of such citrus-waste liquor available in Florida revealed that there is sufficient to produce around 2 million gallons of high-proof alcohol annually. As a result of this work a commercial plant which will produce alcohol from citrus-waste liquor is under construction at Lake Alfred, Fla. Technical assistance is being given to the operator of this plant in the development of methods for the separation of calcium pectate during concentration of the waste liquors and for separation and utilization of naringin from waste liquors of grapefruit canneries.

NEW FRUIT PRODUCTS AND BYPRODUCTS

Because of the present shortage of pectin supplies, a study of methods for preparing washed and dried citrus pomace from cannery residues for use as a commercial pectin base was undertaken, and a very satisfactory product was developed. It will be produced commercially during the 1942–43 season for shipment to Great Britain where the pectin can be extracted with facilities available and under conditions existing in British jam and preserve factories.

In cooperation with the Idaho Agricultural Experiment Station and a commercial cannery, a trial pack of 1,000 cases of prune nectar was prepared from fresh Italian prunes. The product was well received by consumers, and commercial development awaits only the availability of containers and sugar. Sound culls, as well as surplus marketable fruit, could be used in the preparation of this product. It was found that the prunes can be stored for at least 5 weeks at 35° F., before processing, without material loss in the quality of the finished product.

Although clingstone peaches, because of their firm texture, have been used almost exclusively in the past by peach canneries, the canning of soft-ripe freestone peaches is expanding rapidly in the Pacific Northwest on account of their superior flavor. In peach storage studies, which were undertaken to supply the industry with needed information on the best temperatures for holding and final ripening of the fruit, 31° F. was found better than higher temperatures for holding, and temperatures from 65° to 80° were most satisfactory for ripening.

In experiments undertaken for the Quartermaster Corps of the Army on the combination of dried fruits and nuts in bars for special concentrated rations, it was found that very acceptable bars could be made from equal parts of apricots, dates, and figs, with or without nuts. It was found advisable to lower the moisture content to between 12 and 15 percent from the previously specified 19 to 20 percent to reduce the possibility of spoilage. Although nuts improve flavor and food value, they may become rancid in contact with dried fruits under severe storage conditions.

The fixed oil pressed from seeds of Valencia oranges grown in Texas was found to belong to the class of semidrying oils, being low in linoleic acid. It had a bitter taste due to the presence of isolimonin, but this constituent could be removed by refining to make the oil edible.

Kernels from the fruit of the decorative *Cocos plumosa* palm or

plumy coconut, extensively grown in the South, were found to yield 52 percent of a nondrying oil useful for soap making and food products.

In a study of papaya products, formulas were developed for papaya nectars and carbonated beverages.

CEREALS AND SEED PRODUCTS

During the first World War it was necessary to develop supplements and substitutes for wheat flour in making bread, because of an alarming shortage of wheat. At present, even though there is an abundance of wheat, it is desirable to use supplements for wheat flour in order to increase the nutritive value of white bread by adding proteins, minerals, and vitamins in naturally concentrated forms. Analyses of and experiments with numerous samples of wheat germ, a byproduct of flour milling, have shown its value for enriching bread and its suitability for use with white flour in making high-quality bread. A suitable procedure for incorporating the wheat germ with the other ingredients of the bread was devised. Fifteen parts of wheat germ to 85 parts of white flour is recommended. Attention is now being given to soybean flour and peanut flour as supplements for white flour. Baking tests have indicated that excellent bread can be made with 20 percent of soybean flour and 80 percent of a clear-grade wheat flour.

In order to determine if storage of wheat for unusually long periods under the Ever-Normal Granary program might have a bad effect on the baking quality of the flour made from the stored grain, periodic tests have been made on combine-harvested and binder-harvested hard winter wheat of the 1939 crop, and on similarly representative lots of soft winter wheat of the 1940 crop, stored at definite temperatures. With regard to the soft winter wheat, it had been observed at the end of 9 months' storage that the freshly milled flours from the samples representing different methods of harvesting and different storage temperatures all made satisfactory loaves of bread with no appreciable differences between them. After 15 months' storage the soft winter wheat samples still yielded white flours having fairly satisfactory baking quality, those from samples stored at 115° F. being only slightly inferior to those stored at 70°. However, the whole-wheat flours made from samples of combine-harvested wheat stored at 85° and 115° were decidedly inferior in baking quality to those made from samples of binder-harvested wheat stored at the same temperatures. The various samples of hard winter wheat after storage for 27 months at temperatures ranging from 0° to 70° showed no deterioration in milling quality. However, white flours made from portions of these samples at the time the storage experiments were started, and subjected to the same storage conditions, were somewhat low in baking quality and those from combine-harvested wheat were inferior to those from binder-harvested wheat. The differences in temperature of storage (0° to 70°) had little effect.

Laboratory experiments on the compression of flour to reduce its bulk, especially desirable for overseas shipment, showed that the volume can be reduced about one-third by hydraulic pressures of about 1,600 pounds per square inch (or 16,000 pounds on a surface 3½ inches in diameter). Since hydraulic presses are lacking in flour mills, experiments were made with equipment commonly available. A bran packer seemed to offer the greatest possibilities. By suitable

adjustment it was possible to pack, in cotton bags, 25 percent more flour than usual. However, because the tightly packed bags were more nearly cylindrical than ordinarily packed bags, the space required for storing was reduced only about 20 percent.

Experiments are being conducted to develop powdered mixtures of soybean flour, or the emulsifiable portion of soybean flour, with other ingredients, which mixtures may be readily converted into a milklike food beverage by adding water, with or without heating. Such a product might supply the need for a protein concentrate for food uses abroad where milk is scarce.

EGGS AND POULTRY MEAT FOR EXPORT

At the request of the Agricultural Marketing Administration nearly 5,000 samples of dried whole egg, representing lots offered by domestic driers for lend-lease purchase, were examined for total numbers of bacteria and for the presence of particular bacteria which indicate the degree of sanitation under which the powder was produced. About 500 samples were examined for food spoilage and food-poisoning types of bacteria. The information gained from the results of these bacteriological tests and from visits to the drying plants formed the basis of suggestions on how to improve operating practices and arrangements in some plants so as to obtain uniformly sanitary products. Bacteriologists of this Bureau, with their portable laboratory, visited a large number of egg-drying plants in different parts of the country and made a complete bacteriological survey of drying-plant facilities and of raw and finished products. Many suggestions for improvement of equipment and plant operation resulted from these direct contacts and in practically every case the suggestions were followed.

For successful shipment and storage of egg powder and for retention of quality it was found necessary to prevent absorption of moisture from the air. Low temperatures are best for storage. Experiments showed that egg powder stored at 86° F. or higher deteriorates in quality more rapidly than at lower temperatures, as measured by solubility and baking tests and fatty acid determinations.

Also at the request of the Agricultural Marketing Administration, a practical test was developed for evaluating the quality of dried whole-egg powder. This consists of measuring the solubility of the powder, after rehydrating, by either of two methods. After collaborative study by a number of outside laboratories, the test was submitted to the egg-drying industry through the National Egg Products Association and is now used for evaluating dried-egg powder offered for lend-lease purchase.

Since it is desirable in domestic plants to pack dried eggs in small containers for household rationing in Great Britain, a study was made of the relative suitability of various types of small containers for this product.

In order to insure the delivery of a wholesome product to hospitals and convalescent centers near the war zones, information is being developed on proper methods of processing and packing poultry meat to withstand prolonged storage under tropical conditions. Particular attention is being given to the exclusion of food spoilage and food-poisoning types of bacteria.

MORE SUGAR FROM DOMESTIC SOURCES

Pilot-plant experiments on the production of crystallized sugar from sorgo cane indicated the feasibility of developing a commercial process for the manufacture of sugar from this crop. Thus far, yields up to 175 pounds of dry sugar per ton of sorgo have been obtained, together with valuable new byproducts which would help to pay the cost of processing. A fairly satisfactory procedure was developed for separating starch from the sorgo juice before boiling it down. Efforts were made to apply the Steffen process (commonly used in beet-sugar manufacture) to the residual molasses in order to recover additional quantities of sugar. It is believed that, if necessary, both cane-sugar and beet-sugar factories could make sugar from sorgo cane during their off seasons.

With the purpose of learning how to reduce sugar losses in beets awaiting processing, estimated to be around 100,000 tons annually, studies were made in cooperation with an association of beet growers and beet-sugar manufacturers on the effects of three coating treatments for beets and of different storage conditions on the rate of sugar loss. Drying out of the beets and high temperatures accelerated sugar loss, but the maintenance of high humidity or wetting of the beets to prevent drying, and low temperatures retarded sugar loss. Under atmospheric conditions which favored drying out of the beets, coating with filter-press cake from the sugar factory reduced the rate of sugar loss. It is believed the loss could be reduced by half in certain areas.

COFFEE-SUGAR TABLETS FOR THE ARMY

The preparation of quickly soluble coffee-sugar tablets for field use by the Army was investigated and several series of experimental tablets were prepared for testing rapidity of solution and permanence of flavor and aroma. Comments from the Quartermaster Corps indicated that some of the tablets were satisfactory as regards dissolving rate and coffee flavor, but that modification of the formula may be needed to reduce sweetness.

SORGO SIRUP AS A SOURCE OF ALCOHOL

Investigations were started on chemical and technological problems involved in the conversion of sorgo juice into high-density sirup for use as a raw material for producing ethyl alcohol. One of the principal problems is the prevention of excessive viscosity, which may be caused by gelatinized starch or crystallized sugar, in order to permit handling the sirup by pumping. This will necessitate removal of starch or conversion of starch into fermentable sugar. Another problem is the recovery and purification of calcium aconitate, a valuable byproduct, to reduce the cost of processing. Solution of these problems will help Louisiana sugar factories do their part in the program (sponsored by this Department) of growing approximately 100,000 tons of sorgo to be converted by the sugar factories during their idle season into sirup for use by New Orleans distilleries in making alcohol needed by war industries.

BYPRODUCTS FROM SORGO AND SUGARCANE

The principal nonvolatile organic acid in the juices of sorgo and sugarcane is aconitic acid. It first received attention from the Bu-

reau's sugar technologists because, with the lime used in clarifying cane juice, it formed a compound difficult to dissolve, and this compound caused trouble in boiling down sirups because it separated from solution and fouled the heating surfaces. Now it promises to become a valuable byproduct of sugar and sirup manufacture because it can be used in making certain types of synthetic resins and ester compounds which have plasticizing properties. Moreover, it can be easily converted into itaconic acid which has similar uses. Basic research on the chemistry of aconitic acid and its compounds revealed that the mixed tricalcium-magnesium salt is probably the best form in which to separate the acid commercially. Pilot-plant tests indicated that the recovery of aconitic acid from sorgo sirup will average about 16 pounds per 100 gallons, which is equivalent to about 4 pounds per ton of the stripped and topped cane. It is planned to recover calcium aconitate as a byproduct of the high-density sorgo sirup to be produced by Louisiana sugar factories as a raw material for alcohol manufacture. Processes have been developed for making aconitic acid from calcium aconitate and for producing esters of aconitic acid directly from the calcium salt.

Pilot-plant experiments were made on the extraction of sugarcane wax from the dried filter-press cake of the sediment, or mud, obtained as a waste in the clarification of sugarcane juice for sugar manufacture. From 90 to 95 percent of the total extractable matter could be removed with either coal-tar solvents or petroleum solvents at temperatures not exceeding 80° C. (176° F.), provided the muds were in suitable physical condition. The inclusion in the press cake of finely divided fibrous cane residue materially increased the rate of wax extraction. Dried press cakes from raw-sugar factories of Louisiana contain from 5 to 17 percent of crude wax which is composed of about two-thirds hard wax and one-third fatty constituents. Methyl-ethyl ketone was used successfully in pilot-plant operations for extracting the fatty constituents from the crude wax at atmospheric temperatures. Several hundred pounds of the hard wax were produced and distributed among industrial users of waxes for evaluation. The general opinion was that cane wax is not as good as carnauba wax for some uses but is entirely satisfactory for many purposes, either alone or mixed with other waxes. A market for sugarcane wax thus seems assured whenever the product becomes available in commercial quantities.

The fatty fraction extracted from crude cane wax in the refining process contains fatty acids, phytosterol, true oils, and also chlorophyll, carotene (provitamin A), and other plant pigments. Some of these constituents, particularly the sterols and carotene, have potential value as byproducts. The sterols recovered by simple crystallization from a solution of the fatty fraction have responded to irradiation with ultraviolet light to form a product having vitamin D potency. Further research is in progress to determine if the sterols from sugarcane can be used as a commercial source of vitamin D for use in feeds and medicines to supplement the present limited supply from usual sources. Also, experiments are under way to determine the vitamin A value of the natural oil solution of carotene separated from cane wax, and the practicability of separating the carotene from the oil in relatively pure form by adsorption with magnesium oxide or other adsorption agents.

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SWEETPOTATO VINES AND TUBERS FOR FEED

The shortage of suitable material for winter feeding is one of the most serious obstacles to overcome in meeting increased wartime quotas for beef and dairy products in the South. To remedy this condition the Bureau is trying to preserve sweetpotatoes and sweetpotato vines for winter feeding, since in the South the acre yields of sweetpotatoes are much higher in principal nutritive constituents (carbohydrates) than those of corn.

During the past year numerous experiments were made on the preparation and drying of sweetpotatoes in laboratory-size, farm-scale, and commercial-scale drying equipment of various types to learn the relative merits of different designs of dryers and to obtain data on the effects of the various factors that influence drying rate. Some of the driers were of conventional types and others were specially designed for the purpose. Drying experiments were conducted in cooperation with Tennessee Valley Authority, the Southern Regional Research Laboratory, State institutions of Mississippi and Alabama, and two commercial firms. Dried sweetpotatoes were supplied to Mississippi State College and dried sweetpotato leaves and stems were supplied to Alabama Polytechnic Institute for feeding tests.

Successful results were obtained in large-scale cooperative experiments on ensiling mixed sweetpotato vines and cull sweetpotatoes and also sweetpotato vines alone. Feeding of sweetpotato silage from two 8-ton lots put up at the North Carolina Agricultural Experiment Station in October was started in February. In a 90-day feeding test two groups of selected dairy cows, one fed on sweetpotato silage and the other on corn silage, showed no significant difference in maintenance of weight and milk production. The carotene (provitamin A) content of the sweetpotato silage, after about 5 months of curing, was practically the same as that of the best corn silage.

FEEDING VALUE OF HEMICELLULOSES

Studies on the chemistry and nutritive value of the hemicelluloses were continued and were supported in part by an allotment from the special research fund appropriated under the Bankhead-Jones Act. Although these carbohydrate complexes are among the major constituents of all plants, definite knowledge regarding their chemical structure and nutritive value is very limited. An investigation of the chemistry of hemicelluloses in cornstalks was completed. In efforts to develop a satisfactory method for the quantitative estimation of hemicelluloses, which in the conventional method of feed analysis are included in the undetermined fraction called nitrogen-free extract, two analytical procedures for isolating the different hemicellulose fractions were devised and compared. Although the results for total hemicelluloses obtained by the two procedures agreed rather closely, those for individual fractions did not, and further work is required before either procedure can be recommended.

In cooperation with the Bureau of Animal Industry, sheep-feeding experiments with isolated hemicelluloses and plant materials of high hemicellulose content were started. Special attention was given to the hemicelluloses of vines and pods obtained in large quantities as byproducts in commercial canning of green peas and Lima beans. The results obtained thus far indicate that these materials are digested to

a considerable extent by sheep and that the refuse from peas is superior to that from Lima beans in this respect.

VEGETABLE OILS

Investigations were made to determine the best and most economical methods of hulling and drying tung fruits, because carelessness in handling and storing during the several months intervening between harvesting and processing results in poor quality and reduced recovery of tung oil. Treatment of the newly ripened fruits with a 1:1000 mixture of ethylene gas and air for 60 hours greatly facilitated mechanical hulling and was more effective than treatment with steam. If the tung nuts cannot be processed immediately, they should be dried artificially or in properly ventilated barns. Better oil yield (equivalent to 17.8 more pounds per ton) was obtained by pressing tung nuts dried at 135° F. for 18 hours, than by pressing similar air-dried nuts under identical plant conditions. However, the nuts should not be allowed to dry excessively, since less of the kernel substance adheres to shell particles in the decorticating process if the kernels are still pliable. After the decorticated kernels are ground to a meal, careful artificial drying to a definite low moisture content (not allowing the temperature of the meal to rise above 205°) makes it possible to press out more of the oil. By decorticating while the kernels are pliable and partially drying the meal before pressing, it was possible to lower the decortication loss of oil to 0.5 percent and to obtain a press cake containing only 3.5 percent of residual oil, whereas heretofore about 4.5 percent has been considered as the attainable minimum. In cooperative experiments with a commercial firm it was demonstrated that, by using normal hexane as solvent and a countercurrent continuous solvent-extraction process, it is possible to extract about 20 percent more oil from suitably ground tung nuts than when they are processed by the usual expression procedure. A 99-percent extraction efficiency was attained.

Oils were prepared from the seeds of Mexican prickly poppy (*Argemone mexicana*) and nut kernels of the Ecuadorian palm (*Ynesia colenda* Cook) and the yields and characteristics of the oils were determined. In cooperation with the research fellow of the National Cottonseed Products Association, two isomeric tocopherols were isolated from crude cottonseed oil by a newly devised procedure, separated and purified by chemical means, and studied with regard to their antioxident or rancidity-inhibiting value.

Critical studies were made of two methods for determining the number of conjugated double bonds in constituents of drying oils to learn which is better for investigating new drying oils.

USE OF VEGETATION AS CAMOUFLAGE

The investigation of processes for preserving plant materials in natural colors as specimens for scientific use in connection with agriculture, which has been in progress for several years as a basic research project supported with funds appropriated under the Bankhead-Jones Act, has been directed during the past year toward the development of methods for preserving foliage for camouflage purposes. This work was carried out in cooperation with the Engineer Board of the War Department. A confidential report on the results

of the investigation was transmitted by the Engineer Board to the Navy Department and to the British Government. Further improvements have been made in treatments for stabilizing the natural colors of plant materials and a technique has been developed for applying a color-preserving treatment to certain types of dried plant materials, thus eliminating the necessity of starting with fresh material. Consultation service was rendered to the War and Navy Departments on camouflage problems involving the use of foliage and other plant materials.

DESTROYING VEGETATION CAMOUFLAGE

Investigations that were started recently on the effects of industrial contaminants of air, soil and water on crops, and also those on the chemistry of weed eradication, furnished an excellent background for a closely related war-emergency investigation on chemical means for altering the color, texture, and form of foliage of various kinds used by enemies for camouflage, so as to make it detectable to observers in airplanes. These studies were in obverse relationship to similar chemical investigations in which means were sought to accomplish the blending and harmonizing of color and texture qualities in vegetation camouflage as an aid in the protective concealment of friendly installations of military significance. Information of military importance and confidential nature has been obtained in this investigation.

HOW GRAIN STORAGE AFFECTS PROTEINS

For several years investigations have been in progress to determine the nature, rate, and extent of changes in chemical properties and nutritive values of the proteins of grains and other seeds and their milled products as a result of long storage, and to learn how any serious deteriorative changes can be avoided or reduced. The report for 1940 discussed the effects of 2 years' storage under various conditions on the proteins of wheat and flours; that for 1941 discussed the results of similar experiments with corn and soybeans and their meals. In order to get data on wheat stored for longer periods laboratory feeding tests, similar to those made in previous storage experiments, were conducted with samples of wheat that had been stored 4 or 5 years in large experimental bins in Iowa, Kansas, and North Dakota. Since data were not available on the nutritive value of the wheat at the time it was placed in storage, the results of the feeding tests could not show whether there was any deterioration in nutritive value as a result of storage. However, they did show sufficiently high nutritive value to justify the conclusion that serious deterioration had not occurred during storage. Studies on the same samples to determine their chemical properties led to the same conclusion.

The investigations conducted thus far indicate that the effects of storage upon the proteins in grains depend on moisture content, temperature, degree of maturity of grain when harvested, how the grain is handled between harvesting and storing, the type of storage bins employed, kind and variety of grain, and length of storage. Low moisture content and low temperature are essential for the best results. Varieties of hard wheat having high protein content deteriorate less in storage than soft wheat which has a low protein

content. Whole, unground grains are less affected by storage, with regard to deterioration in proteins, than are their meals or flours similarly stored. Some kinds of grain deteriorate more in storage than others. From the evidence thus far obtained it appears that wheat, in sound condition and having a relatively low moisture content, can be held under good storage conditions for several years without serious loss in the nutritive value of its proteins.

IMPROVING PROTEIN VALUE OF FOODS

Studies on the food value of the proteins in soybean meal, particularly as affected by processing methods, showed that heating the meal under certain conditions increases digestibility of the proteins because it makes some of the amino acids more available for assimilation; also that the proteins in ground soybeans containing the original oil are more digestible than the same proteins in ground soybeans from which the oil has been removed by solvent extraction when both preparations are tested by the same methods after the same heat treatments. These observations are significant in connection with the processing of soybeans and the production of soybean meal of maximum nutritive value for use in feeds and foods.

An investigation on the effect of feed on the protein quality of hen eggs, carried out in cooperation with the Bureau of Animal Industry for the purpose of improving the protein value of eggs by feeding suitable rations, showed that eggs from hens fed a high-protein ration are inclined to have a higher cystine, tyrosine, and arginine content than eggs produced by the same hens on a low-protein ration. The possibility of thus changing the relative proportions of individual amino acids in the proteins of eggs is important from the standpoint of eggs as a staple food and possibly also from that of eggs for hatching. Determinations of individual amino acids in eggs and newly hatched chicks gave lower values for those in chicks, except in the case of cystine. Apparently some cystine is synthesized by the developing chick embryo.

In view of a threatened shortage of animal-protein foods (meat, milk, and eggs) investigations were started to determine the value of proteins in soybean, peanut, and cottonseed flours for partial replacement of animal proteins in the diet and also for supplementing deficiencies of certain amino acids in the proteins of cereal grains. Preliminary experiments have shown that a mixture consisting of only 10 parts of peanut flour and 90 parts of wheat flour has a growth-promoting value more than twice that of wheat flour alone. Peanut flour of good quality containing between 50 and 60 percent of protein is being prepared commercially in limited quantities. Such flour, added to wheat flour in suitable proportions, corrects deficiencies of the latter by supplying not only protein containing nutritionally essential amino acids, but also needed vitamins and minerals.

A second sulfur-containing amino acid, somewhat similar to one discussed in the report for 1941, was discovered in keratin-containing substances and in milk albumin. These new amino acids, which were named mesolanthionine and racemic lanthionine, are related to cystine and methionine, two sulfur-containing amino acids that are essential for animal nutrition and vital physiological processes. Feeding experiments to determine their nutritional value are in progress.

It was found that the indigestible proteins of feathers, hair, and other keratins can be converted into digestible proteins which contain some nutritionally essential amino acids by treating with dilute sulfide solutions. Their value as sources of these amino acids in animal feeding remains to be determined.

PREVENTION OF BIN BURNING IN GRAIN

Experiments on a pilot-plant scale to increase the keeping quality of grain by artificially ripening were tried immediately after harvest on wheat at Manhattan, Kans., and on corn at Ames, Iowa. These experiments, suggested by studies on the enzyme systems in wheat, represent an expenditure of both Bureau and Bankhead-Jones funds. The ripening agent used was ethylene. The wheat experiment showed that when immature wheat, containing 18.2 percent moisture, was treated with ethylene immediately after harvest, it remained in good condition for 10 months thereafter and produced flour of marketable quality. Similar but untreated grain harvested at the same time spoiled from bin burning in about 3 days. This experiment seems to point to ethylene as a useful agent in treating some kinds of wheat, particularly wheat which for one reason or another has had to be harvested a little too soon. The cost of the material used in the treatment is very small (about 0.001 cent per bushel). The fire underwriters appear to be convinced that the process is not risky.

Similar experiments with ethylene were made to see if freshly harvested corn could be shelled at once and stored in bins immediately after treatment. Storage of shelled corn has not been successful because the corn heats up in the spring. It is an important objective, however, because the farmer could sell his corn at once instead of keeping it over the winter on the cob, thus saving labor, storage space, and interest on the investment. The experiments, however, indicated that ethylene in the concentrations used (the same as were successful with wheat) had little or no effect on storage of the shelled corn. Further experiments with other gases showed that carbon dioxide may possibly be useful in preventing the bin burning of shelled corn. This is an indication only and no definite statement can be made until further work has confirmed or disproved it.

CONTROL OF ENZYMES TO CONSERVE FOODS

Experiments on the digestion of meat by papain have shown that under proper conditions the meat rapidly liquefies. The liquid is easily sterilized and dried. The dried product has a pronounced meat flavor and contains practically all of the B_1 vitamin originally present in the meat. Because of its stability the product may have possibilities as a meat substitute.

No evidence has been found that vitamin B_1 is destroyed by enzyme action in ordinarily used agricultural products. On the other hand, the loss of vitamin A is sometimes caused by enzyme action. This points to the necessity of destroying the enzyme which causes vitamin A loss in food products that contain considerable amounts of this enzyme, such as soybeans and kale. However, the enzyme is easily destroyed by heat, and since most vegetables are blanched in processing, the loss of vitamin due to this action has probably been overrated.

In cooperation with the Puerto Rico Agricultural Experiment Station a new process for curing vanilla was worked out as a result of enzyme studies made on the fresh beans. The process consists of freezing the beans before proceeding with the classic method of treatment. The quality of the product is quite considerably improved by this means. A public patent on the method has been granted.

A new protein that occurs in small quantities in wheat, recently discovered by the Enzyme Research Laboratory, was obtained in crystalline form. A study of this protein showed that while it is harmless to animals when fed, it is toxic when injected. It is also very toxic to certain bacteria (not to all) and to yeasts. The existence of this material in wheat explains why wheat is not as easily fermented to alcohol as other grains. The production of alcohol from wheat is therefore being investigated in this laboratory with the object of overcoming the bad effect of this constituent of the grain. Experiments were also made to find out if this material could be used as a food preservative but so far its usefulness in this connection does not seem to be very great. The material is being investigated by several institutions for medical research in view of the possibility that its toxicity toward bacteria may make it useful in the treatment of certain infections.

Further work on the preservation of foods with wood smoke has been carried on. Methods have been developed whereby the penetration of smoke can be measured and as a result it has been shown that very little smoke gets into meat treated by the quick-smoking process now used commercially. Smoke is a very efficient preservative, however, and methods of getting more smoke into the meat quickly are being studied.

SPECIAL RESEARCH IN AGRICULTURE

The Bureau continued to participate in the Department's program of basic research in agriculture under the Bankhead-Jones Act of June 29, 1935. Projects that were supplementary or closely related to certain activities under the regular appropriations for this Bureau are covered in statements regarding these activities elsewhere in this report. These include chemical investigations on hemicelluloses, enzymes, animal viruses, and the preservation of plant specimens; also engineering investigations on high-density packaging of cotton at gins and farm storages for corn, grain sorghum, and other grain. Only the results of special research on allergens and soybean products are reported here. Information on other Bankhead-Jones projects is given under the following subheadings: Feeding value of hemicelluloses, use of vegetation as camouflage, prevention of bin burning in grain, farm structures for storing crops, and making cotton bales better at gins.

RESEARCH ON ALLERGENS ENCOUNTERED UNDER WAR CONDITIONS

The investigation on the chemistry, biological nature, and functions of allergens of agricultural products, which has been carried on as a basic-research project supported by allotments from the special research funds appropriated under the Bankhead-Jones Act, was directed toward the acquisition of new scientific information that

would help in controlling allergic diseases in the armed forces and among the workers in war industries. It has been estimated that at least one-tenth of the population suffers from some form of allergy, manifested variously as hay fever, asthma, dermatitis, or digestive disorders, due to exaggerated sensitiveness of some individuals to minor components of organic substances that are harmless to most people. Allergens may be present in foods, textile fibers, furs, organic dusts, plant pollens, and in finishing materials for leathers and fabrics. Under war conditions many susceptible persons come in contact with allergens that normally would not be encountered or that could be avoided by change in diet, residence, or occupation. Although they suffer much discomfort, the most serious result from a national standpoint is impairment for work or military duty with loss of efficiency and valuable time.

Much information has already been developed with regard to the composition, properties, and physiological effects of the allergens in cottonseed and some of its products, and the chemical characteristics and biological nature of allergens in wheat products, ragweed pollen, and some kinds of organic dust. This information is useful in the diagnosis and management, and possibly the alleviation or prevention of certain allergic ailments. Fundamental research on the identity and properties of the allergenic components of such organic materials is prerequisite to the development of effective means of making them innocuous.

The special methods developed for the isolation and identification of the allergens in cottonseed during the exploratory phase of this research are being applied to somewhat similar allergens in the castor bean, a strategic raw material for several products having war uses. Attention is also being given to other oil seeds to determine the relationship between allergenic activity and chemical composition of the seed proteins. Allergenic activity is a factor of increasing importance in developing acceptable substitutes for foods, natural fibers, wood, leather, and rubber.

FAST-DRYING OIL FROM SOYBEANS

The selective-solvent extraction method for fractionating soybean oil into fast-drying and edible portions was investigated with outstanding success by the U. S. Regional Soybean Industrial Products Laboratory. Starting with soybean oil having an iodine number of 132, it was possible with small pilot-plant equipment to obtain, in different trials, fractions representing yields of 40, 28, and 12 percent having iodine numbers of 168, 176, and 184, respectively. When heat-bodied and used in the formulation of ester-gum varnishes, these fractions produced films having excellent water resistance and durability. The drying fraction is equal or superior to linseed oil, which must now be imported in large quantities, and the edible fraction appears to be more suited than other oils for food purposes. The fast-drying fraction can also be further processed to produce excellent substitutes for tung oil, in which a critical shortage has developed. Industrial application of the process would contribute materially to filling our needs for over a billion pounds of drying oils per year, most of which have heretofore been imported.

PLASTICS FROM SOYBEAN MEAL

Several industrial companies are now using a modified soybean meal in the manufacture of phenolic-type plastics because the U. S. Regional Soybean Industrial Products Laboratory showed that the addition of a modified soybean meal to phenolic-type plastics results in a product superior in some important respects, such as improved flow and color stability, as compared with regular phenolic plastics prepared from 50 percent phenolic resin and 50 percent wood flour.

It has been demonstrated that the addition of small percentages of water-leached and heat-denatured soybean meal or heat-denatured soybean protein greatly increases the plastic flow of a phenolic resin-wood flour plastic without altering appreciably the strength of the finished product or other important properties. A number of light-resistant dyes have been found to be suitable for coloring the soybean-phenolic plastic. Excellent molding powders have been prepared containing 50 percent soybean meal, 35 percent phenolic resin, and 15 percent wood flour. A substantial saving in phenol is possible by the use of soybean meal in the phenolic type of plastic.

REGIONAL RESEARCH LABORATORIES

(Conservation of Agricultural Resources, under Agricultural Adjustment Act of 1938)

SYNTHETIC RUBBER

The Northern Regional Research Laboratory developed an improved process for making butylene glycol by the fermentation of corn and wheat, and by the end of the fiscal year was producing this relatively rare chemical on a pilot-plant or semicommercial scale. Butylene glycol is a rather viscous liquid resembling glycerine in its properties and may be used in making antifreeze for automobile radiators and in other commercial products.

Butylene glycol is being studied particularly as a possible link in the production of butadiene, the basic material used in the manufacture of the Buna type of synthetic rubber. Special interest lies in the production of butadiene from butylene glycol because it is believed that the yield of butadiene per bushel of corn or wheat will be higher by way of butylene glycol than by way of alcohol. Three steps would be involved in the production of rubber from agricultural crops by this method—raw material to butylene glycol, butylene glycol to butadiene, and butadiene to rubber. The final step, production of synthetic rubber from butadiene is already known. The major problem remaining is conversion of butylene glycol to butadiene on a commercial scale.

The fermentation process involved is simple and requires essentially the same type of equipment now available in large commercial alcohol plants.

Every step of the process, from selection of the best micro-organism for the fermentation, through economic recovery of pure butylene glycol, to efficient conversion of butylene glycol to butadiene, is receiving intensive and thorough study.

Excellent yields of pure butadiene have been produced from corn-made butylene glycol in the laboratory, and it is expected that the

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conversion process will soon be tried on a pilot-plant scale to obtain data bearing on its commercial application. The information obtained is being made available to all industries concerned with or likely to be concerned with the problem in the hope that the production of butadiene in this manner may aid in filling the country's critical need for synthetic rubber in the present emergency.

RUBBER SUBSTITUTE

Norepol is the product resulting from a discovery by the Northern Laboratory that certain polymers from soybean, corn, and other vegetable oils may be compounded and processed to yield a product which may be milled, calendered, and vulcanized with conventional rubber processing equipment. This rubberlike material, which has promising possibilities, has created a great deal of interest and samples have been submitted to oil-processing companies, rubber fabricators, and consumer-goods manufacturers for testing and evaluation.

In its present early state of development, Norepol has the following characteristics after compounding and vulcanizing in rubber molds for 30 to 45 minutes at 280° F.: Tensile strength, 300–865 pounds per square inch; elongation at break, 100–250 percent; tear resistance, 30–80 pounds per inch; Shore-Durometer hardness, 20–80; and brittle point, −23° to −40° C. The rather wide range in properties listed is due to variations in amounts and type of compounding ingredients used.

Observations on the effects of contact with solvents and oxidizing gases at room temperature, unless otherwise indicated, were as follows: Water, no apparent effect; oxygen, no break-down in oxygen bomb at 80° C., 50 pounds per inch after 48 hours (tensile strength increases); ozone, no apparent effect in 10-hour exposure; petroleum ether, very little swelling but embrittles rapidly; Skellysolve F, very little swelling but embrittles rapidly; motor oil, SAE 30, swells much less rapidly than rubber; ethyl alcohol 95 percent, no apparent effect; and aromatic hydrocarbons, immediate swelling, and loss of strength.

STARCHES FROM WAXY CORN AND SORGHUM

Since importation of tapioca starch from the East Indies has ceased, a substitute for it must be found for use in the adhesive and woodworking industries. Waxy grains are of promise for this purpose, for waxy-grain starches have properties more like the root starches than the ordinary cereal starches.

Leoti and Schrock waxy sorghums are commercially available; other varieties of waxy sorghum and several varieties of waxy corn have been grown only for experimental purposes. Available varieties of these waxy cereals have been processed for starch by the Northern Laboratory. Leoti and Schrock sorghums, when subjected to the normal wet-milling process, yield colored starches. However, it has been discovered that pearling of these cereals to remove the colored seed coat yields a colorless starch. Excellent yields of high-quality starch were obtained from waxy corn and some waxy sorghums. No difficulties were encountered in carrying the laboratory process through the pilot-plant stage.

Waxy cornstarch gives a translucent, nearly tasteless paste with a high viscosity. The paste does not gel on cooling, but remains highly

viscous. In these properties it closely resembles tapioca starch. Waxy-sorghum starch pastes have been found to have similar properties, but none of them have been obtained without a pronounced flavor.

Different types of starches have been dextrinized by the Laboratory for comparative purposes. Waxy cornstarch and waxy-sorghum starches changed to dextrin at considerably lower temperatures than did any of the other starches examined. These dextrins yielded adhesive films which compared well with those obtained from commercial tapioca dextrins with regard to bonding strength, clarity of films, and remoistening properties, including speed of developing stickiness. In all cases, the waxy-sorghum and waxy-corn dextrins were superior in these properties to the tapioca, corn, and wheat dextrins prepared under identical laboratory conditions. The substitution of tapioca starch by waxy-grain starch for many purposes, therefore, seems to be very promising.

Waxy-grain starches have been found to differ fundamentally from the well-known starches in chemical structure. In contrast to ordinary starch, which consists of branched-chain and linear molecules, the waxy-grain starches appear to consist only of the branched-chain type.

PLASTICS FROM AGRICULTURAL RESIDUES

During the past few years the use of plastic bottle caps as a substitute for the old-fashioned cork stopper has received widespread acceptance. Because of the critical position in the present emergency of the phenolic plastics formerly used for this purpose, the Northern Laboratory was appealed to by industry for aid in the solution of this problem. A new plastic molding powder composed of about 85 percent of agricultural residue materials and only 15 percent of phenol-formaldehyde compound has been developed. This molding powder has been fabricated into bottle caps on commercial machines and is now ready for acceptance by industry. The adoption of this agricultural plastic material in industry, together with some war uses for which it will also be adapted, may result in the use of approximately 70,000 tons of agricultural residues annually.

CORK SUBSTITUTES FROM RESIDUES

Cork is now lacking for many civilian uses, notably for the closures needed for the bottling of soft drinks. Estimates indicate requirements of about 35,000 tons of granulated-cork replacements. Partial substitutes exist in the pithy constituents of cornstalks, sugarcane, peanut shells, and other similar materials.

The Northern Laboratory has developed a resilient disk, composed in part of the pith from peanut shells or other agricultural residues, which, after careful testing by the manufacturers of soft drinks, was stated to be fully equal to cork formerly used for this purpose. Based on these tests and the desire of a number of the large users for the opportunity to manufacture this substitute, the problem is now undergoing pilot-plant study. Should this new material be accepted by industry, it is estimated that a potential use of 15,000 tons annually of agricultural residues can be counted upon for this purpose, in addition to other agricultural products contained in the material.

ANTISEPTIC AGENT FROM CORN SUGAR

A new antiseptic, penicillin, formed by the growth of a mold *Penicillium notatum* on solutions of corn sugar, is now undergoing extensive clinical tests for the treatment of wounds and burns. This material has almost ideal properties for use in combating internal and surface infections, inasmuch as it can be used intravenously, orally, or topically, and is entirely nontoxic to mammalian tissues. Discovered by the English, it has been found to be very efficacious in the treatment of gangrenous infections and burns. The development work on the production of penicillin which the Office of Scientific Research and Development, Office for Emergency Management, requested the Northern Laboratory to undertake has resulted in a great increase in the yields and ease of production of this material and brings its actual clinical use much nearer. The commercial production of penicillin may well be the biggest advance in the treatment of infections since the sulfonamide drugs were developed. The importance of a drug of this type in wartime is quite apparent.

LINT COTTON FOR SMOKELESS POWDER

Work on the utilization of lint cotton in the manufacture of smokeless powder, begun during the previous fiscal year because of a possible shortage of linters for this purpose, was continued at the Southern Regional Research Laboratory. Through the cooperation of a commercial linters purification plant and the Naval Powder Factory, several tons of short-staple Middling and Low Middling cotton were cut on two available types of commercial machines, purified, and manufactured into smokeless powder. Both grades of cotton proved entirely satisfactory, but the Low Middling was purified with considerable difficulty. The capacity of the cutting machines was not as great as required, however, so a new disk-type cutter was designed and built which gave highly satisfactory results. Plans are now being drawn for the construction of a commercial-size unit having an estimated capacity of 10 to 15 tons of cotton per hour.

The Southern Laboratory also investigated the possibility of substituting cut lint cotton for linters in making cellulose acetate and other cellulose derivatives. Acetylation tests in cooperation with commercial purifiers of cotton linters for cellulose acetate showed that cut lint cotton purified by the usual methods may be suitable for acetate rayon, but not for plastics. In testing cellulose acetate, it became evident that new plasticizers were necessary because of limited supplies of the usual materials. The plasticizers developed, consisting of certain heterocyclic amides, proved very satisfactory and are being patented. Preliminary experiments indicated that cut lint cotton can also be used as a raw material for viscose.

With the object of improving the stability of nitrocellulose for smokeless powder, cotton-fiber preparations were methylated before nitration. Preliminary tests were encouraging but later work was inconclusive. Further experimentation is required.

REPLACING IMPORTED FIBERS WITH COTTON

Binder twine is an essential item in harvesting a large part of the Nation's small grain and other crops. Supplies of binder twine, now made from imported henequen and sisal, are likely to be inadequate

for 1943. Research on the development of a satisfactory cotton binder twine is being conducted in cooperation with a large twine manufacturer. Test lots of experimental twine were manufactured and shipped to an agricultural experiment station in the Grain Belt for actual field tests in harvesting wheat. The amount and nature of further research will depend largely on the results of these tests.

Research undertaken at the request of the Office of Civilian Defense on the production of rubberless cotton fire hose resulted in the development of a special treatment for cotton yarns that gives them wet-swelling properties very similar to those of linen, which is now used for this purpose. Fabric woven from the treated cotton yarns compared favorably with the better types of linen fire hose in resistance to water penetration. Arrangements are being made for commercial trials.

Burlap and cotton bags are essential for handling almost every kind of agricultural commodity. War in the Far East has greatly reduced supplies of burlap, and cotton fabrics will be required to supply most of the deficiency. Wartime requirements for cotton-bag fabrics, by width, weight, and construction, have been determined, and this information has been furnished to the Office of Agricultural War Relations and the War Production Board. The statistical information and technical advice furnished under this project is aiding in the efficient use of available bag fabrics and helping to insure adequate quantities for the future. Approximately 1.5 billion yards of cotton fabrics will be required annually for this purpose until burlap is again available in normal quantities.

PROCESSING COTTON FOR MILITARY USES

Work undertaken at the request of the Supply Division, Corps of Engineers, United States Army, embraced an extensive examination of rotproofing treatments applied to fabrics intended for sandbags and camouflage purposes. To evaluate samples of treated fabrics submitted for test and samples prepared in the laboratory, soil-burial, weather-exposure, accelerated-aging, and leaching tests were employed. The resulting information furnished to the Corps of Engineers has made possible the designation of approved rotproofing treatments for large orders of Army fabrics.

Fireproofing of cotton fabrics was accomplished by means of substituted phosphoric acid esters. The diphenylphosphoric acid ester of cellulose is fireproof, even with a phosphorus content of only 1.5 percent, and it is also stable to washing treatments but, unfortunately, esterification causes a considerable loss in fiber strength. Several methods of preparation were evolved, but this defect was not overcome.

An attempt was made to improve the resiliency of cotton fiber by incorporating a synthetic elastomer such as the copolymer of butadiene and acrylonitrile. Polymerization took place in the liquid and vapor phases but principally as a surface reaction. The objective of complete polymerization within the lumen of the cotton fiber was not attained, although microsectioning revealed that a small amount of polymerization had occurred inside the fiber.

A study was made of water-repellent and waterproofing compounds suitable for fabric application, including stabilized wax emulsions, quaternary ammonium compounds, and synthetic resins and plastics.

Numerous samples of treated fabric were prepared by impregnating and coating methods, and suitable apparatus was provided to measure in several different ways the resistance of such samples to water penetration. An attempt is being made to prepare a treated fabric which will have a high degree of water resistance while retaining its porosity to air.

NOVEL DEFENSE USES FOR COTTON

Weather-resistant transparent plastics reinforced with wire mesh are being used extensively for replacing window glass in localities subject to bombing attacks. Research is being conducted on various types of cotton-mesh fabrics which might be used to replace wire mesh as the reinforcing material. Films have been applied by both dipping and laminating processes to samples of cotton mesh to determine their relative suitability for this purpose. The durability, light transmission, and other properties of the samples are being studied in comparison with similarly treated wire mesh.

As shatterproof coatings for window glass, a number of cellulose acetate formulations gave good results when tested against commercial products by a blast method developed in the Southern Laboratory.

An investigation of cotton cloth as a blackout material is in progress. This involves a study of the influence of structure and finish on the opacity of a fabric.

Cotton-reinforced plastics were found satisfactory for molding helmets suitable for civilian use during air raids.

Regenerated cellulose of the sausage-casing type, which is prepared from cotton linters, was tested as a substitute for tin in collapsible containers. It is satisfactory for packaging products free from water, such as petrolatum and ointments.

RECOVERY OF SEED OILS FROM PRESS CAKE

Pilot-plant equipment of the diffusion-battery type for extracting oil from cottonseed and peanut press cake and meal, capable of handling over a ton of meal daily, was designed, built, and installed. The individual units performed satisfactorily in preliminary tests, and the equipment is being made ready for actual extraction runs. Recovery of edible vegetable oil from cottonseed and peanut cake by this solvent-extraction method will add about 200,000,000 pounds to the annual oil supply.

REPLACING IMPORTED OILS WITH MODIFIED DOMESTIC OILS

Before the war spread to the Pacific Ocean it was recognized that if the sources of palm oil in the East Indies and Malaya were cut off a suitable substitute made from domestic materials would eventually be required, since 40,000,000 pounds of palm oil is consumed annually in this country in the production of tin and terne plate and in the cold-reduction process for the manufacture of strip steel. Consequently work was begun on the development of such a substitute in the latter part of 1941. An examination was made of the chemical and physical properties of virgin and spent palm oils, and these oils were compared with hydrogenated cottonseed and peanut oils under conditions obtaining in the molten-tin bath. On the basis of the results and of information from various cooperating producers and consumers of tin plate, a selectively hydrogenated cottonseed oil having an iodine

number of approximately 50 was developed. This oil was not only equal to palm oil for use in the production of tin and terne plate, but was found to be superior with regard to rate of change in viscosity, free fatty-acid formation, loss of oil due to volatilization, increased fire and flash point, fluxing properties, and especially duration of utility in the tin bath. Specifications have been prepared for the manufacture of this oil which can be made available by oil processors whenever needed.

There is also a shortage in technical grades of olive oil which was previously imported from the Mediterranean area for use in the textile industries as a lubricant, as a soap or detergent and, after sulfonation, as an emulsifying agent. Work was begun on the development of an olive oil substitute, especially for sulfonation. Progress has not been so rapid as on the palm oil substitute, because of concentration on that project, but indications are that a satisfactory, if not superior, sulfonating oil can be developed from cottonseed or peanut oil or both.

Similar work has been undertaken to develop substitutes for coconut-oil fatty acids and for imported hard waxes. A number of synthetic waxes were prepared and sent to various processors and consumers for evaluation as substitutes for imported carnauba, candelilla, and Japan waxes.

EXPANDING USES OF OILSEED MEALS

Efforts have been made to adapt cottonseed and peanut meals and proteins for use in adhesives, sizes, cold-water paints, and synthetic wool-like fibers because the war has greatly reduced supplies and availability of materials commonly used for these purposes. Peanut protein was found to have properties that make it suitable for use in paper coatings and synthetic fibers. Both cottonseed meal and peanut meal, as well as certain protein fractions derived from them, were shown to be adaptable to the production of paper adhesives and glues for the manufacture of plywood and veneers.

Work was completed on the determination of yield of recoverable protein from various commercial oilseed meals and on the control of the color of proteins intended for use in the production of sizing and synthetic fibers. The gluing and adhesive properties of a number of commercial cottonseed and peanut meals were compared with those of casein, starch, soybean, and other commercial adhesives. The results obtained indicate that a suitable, if not superior, product for certain gluing operations can be developed from the oil-free meal or protein of either cottonseed or peanuts.

STARCH AND CAROTENE FROM SWEETPOTATOES

Major efforts were concentrated on increasing the production and improving the quality of sweetpotato starch to supplement imported cassava starch for special industrial and war uses. All possible technical advice and assistance, based on intensive laboratory and pilot-plant investigations, were given to the Laurel starch plant. Both the yield of starch per bushel of sweetpotatoes and the quality of starch produced by this plant were higher in 1941–42 than ever before. Advice was also given on the selection of equipment and processes for application of the Laurel process in a large commercial sweetpotato-starch enterprise at Clewiston, Fla.

In an investigation designed to develop an economical process for extraction and purification of carotene (provitamin A) from sweetpotatoes, carotene was obtained in crystalline form by three different processes.

PROCESSING FRUITS FOR FOOD

Preservation of fruits by spray drying to effect maximum retention of nutritive values and flavor has been actively studied at the Western Regional Research Laboratory. Except for lemons, which are converted to a powder containing about 80 percent of added dextrose, no fruits are dried commercially by this method and little is known concerning its possibilities. Information essential to successful spray drying of fruits has been developed and reasonably satisfactory products have been obtained from navel and Valencia oranges, grapefruit, strawberries, boysenberries, and persimmons. Color, flavor, and vitamin retention were encouraging; in some cases the dried product retained as high as 80 percent of the vitamin C and all of the vitamin A originally present. The dried fruits obtained in the form of powders, with less than 5 percent residual moisture, keep without addition of preservatives. They may be rehydrated readily to make jellies, butters, sirups, beverages, dessert mixes, and bakery goods.

An urgent problem which required attention during the 1942 season was the adaptation of freezing preservation to the large commercial crop of apricots in California, for bakers' supplies and baby foods, which could not be canned as usual for lack of tinned containers. It was found that exposure of apricot halves to live steam for 2 minutes or more before freezing prevents discoloration and flavor alteration during freezing, storage, and defrosting. Apricots treated in this way can be frozen without addition of sugar and used for pies, jams, preserves, and baby food.

Peaches and apricots frozen whole without preliminary treatment could be peeled with acid or lye while still frozen, and after defrosting at or near the boiling point of water were in excellent condition for canning. This provides a means of prolonging the canning season for peaches and apricots by several months.

Cooperative work with the Agricultural Marketing Administration provided data used as a basis for the establishment of tentative commercial grades for frozen peaches, raspberries, and strawberries.

A rapid, accurate method for the determination of ascorbic acid (vitamin C) in fruit was developed.

Fruit wastes and culls were used experimentally as media for the production of yeasts high in vitamins and proteins that are suitable for food, feed, and pharmaceutical purposes. High yields of a wild yeast (*Torula utilis*) were obtained in prune, peach, raisin, pear, apple, and fig juices without added growth factors. The protein content of this yeast proved to be about 55 to 60 percent.

EMERGENCY USES FOR APPLES

Tragacanth, acacia, and other water-soluble gums normally imported in quantities of about 24,000,000 pounds a year from Eastern Mediterranean countries are now available only in very limited amounts due to the war. Because of its unique physical properties pectin was studied by the Western Laboratory as a possible substitute. It was found to be satisfactory as an emulsifying agent in preparing

stable emulsions of mineral, olive, and cottonseed oils in water. At the request of the Navy Department pectin-containing formulas were developed for a tannic-acid jelly, for treatment of burns, and a washable-ointment base to which "sulfa" drugs may be added for treatment of minor injuries or infections. These formulas have met with favorable acceptance and have been published by the American Pharmaceutical Association and recommended to pharmacists throughout the country.

Recent work on a modified pectin as a replacement for imported agar in bacteriological work showed great promise. A pectin derivative was prepared which forms clear, stable gels that can be sterilized in a pressure autoclave without change. When used with appropriate nutrient media, cultures of several organisms have been found to grow readily. Adequate quantities for testing in a number of bacteriological laboratories are now being prepared.

Experiments on the preservation of apples by spray drying led to a satisfactory powdered whole-apple product which can be rehydrated readily for use in such products as jellies, butters, beverages, sirups, and bakery goods. The low moisture content favors preservation without sulfur dioxide or other preservative and good retention of flavor and nutritive values.

In cooperation with the Delaware Agriculture Experiment Station, which originated a low-methyl ester pectin from apples which will produce stable gels at any sugar concentration, pilot-plant studies were carried on by the Eastern Regional Research Laboratory for the development of the product. This special pectin can be used to prepare gels over a wide range of sugar concentration, whereas ordinary pectin requires 65 percent sugar to produce a satisfactory gel. It is thus a very definite sugar-saving article.

Based on preliminary laboratory studies at the Eastern Laboratory, pilot-plant equipment was designed and constructed for the preparation of an apple-juice concentrate which retains the original apple flavor and aroma. This product should make a very acceptable table sirup. A second type of apple-juice concentrate was also developed; the color, flavor, and acidity were removed, leaving a bland, very sweet, high-levulose sirup like the invert-sugar sirups of commerce now made from granulated sugar. In addition to serving as a sugar supplement, this product, due to its high levulose content, appears promising for use as a humectant to replace glycerine in smoking tobaccos.

INDUSTRIAL PRODUCTS FROM FRUIT WASTES

Examination of potential sources of seed oils to supplement inadequate domestic supplies was extended to a variety of fruit-seed kernels and nuts. Attention was also given to the development of new uses for the fatty acids necessarily obtained as byproducts in the increasing production of glycerine from oils and fats for war needs. Methods of recovery and properties of the oils were determined. Research on derivatives of these fatty acids yielded some very promising plasticizers for vinyl and cellulose types of plastics.

A process was developed by the Western Laboratory for recovering tartrates from dilute and hitherto unworkable winery wastes, and work is now proceeding on pilot-plant operation of the process at a cooperating winery. It is anticipated that this process, which is based

on an entirely new principle in tartrate recovery, will make possible adequate domestic production of tartaric acid.

Studies directed toward development of a continuous and simplified method of pectin recovery from fruit wastes resulted in a process, based on a new principle, which in preliminary laboratory tests has shown considerable promise.

USING PLANT PIGMENTS OF ALFALFA

Green pigments prepared from alfalfa are being tested by the Western Laboratory for their value in camouflage work. Dried meals, concentrates, and derivatives of the natural green pigments have been prepared and tests have been made on the stability of the various preparations when exposed to weathering. Both infra-red and visible-light reflectance and photographic properties of the preparations were studied. Also, estimations were made of comparative tinctorial power, relative costs of preparation and transportation, and probable availability of the several required raw materials.

Extensive studies have been carried on by the same laboratory on the preparation of carotene (provitamin A) from alfalfa. The war has caused shortages in fish-liver oils, heretofore among the principal sources of vitamin A, and it is important that new sources be found. In one phase of the work, concerned with storage of alfalfa meal, it was found that maintenance of an atmosphere containing less than 3 percent of oxygen will protect the carotene. In another phase, concerned with the carotene-stabilizing effects of various anti-oxidants, it was found that diphenylamine was the most effective of about 100 different substances, tried in carotene-containing compositions pressed into pellets. Recent tests showed that stability of the carotene is affected by the original carotene content of the prepared pellets. In the study of methods for economically recovering carotene from alfalfa an evaluation was made of the importance of enzymic destruction of carotene. The danger was found to be slight if the alfalfa is dehydrated promptly with heat.

PACKING POULTRY PRODUCTS BY FREEZING

Freezing preservation was applied experimentally by the Western Laboratory to dressed poultry, cut-up poultry meat, precooked and boned poultry meat, and broken-out eggs under conditions selected for maximum retention of quality. A storage temperature of 0° F. or below was found necessary for keeping frozen poultry in good condition. Properly frozen poultry, both drawn and undrawn, was in excellent condition after storing 5 months at −20° and would probably keep much longer at that temperature. It was found that frozen-egg mixture stored, even for short periods, must be kept at subfreezing temperatures to preserve quality. Marked deterioration took place in 15 days when stored at 33°, and after 20 days at this temperature the product was not fit for human consumption. It was also found advisable to mix broken-out eggs before freezing; otherwise the yolks acquire a leathery texture which is apparent even after frying.

PRESERVING EGGS WITHOUT REFRIGERATION

A method of sterilizing broken-out whole eggs by means of short-wave radiation and mechanical vibration is being studied; such a

method, if successful, would be of value in conjunction with spray drying and in situations where refrigeration might be difficult.

An investigation is under way at the Western Laboratory on the vitamin content of eggs produced by hens on different experimental rations, and the effects of dehydration and storage on the retention of vitamins in dried eggs. Results obtained thus far show that eggs can be spray-dried with no important loss of vitamin A, thiamin, riboflavin, pantothenic acid, or nicotinic acid. Selected eggs have been broken out, mixed, and dehydrated under controlled conditions. The products have been stored under conditions representing a variety of storage, transportation, and packaging practices and tested periodically by chemical and biological methods for changes in quality. The results obtained thus far indicate some deterioration in a relatively short period of time when the dried eggs are stored under the usual conditions of commercial practice.

UTILIZING POULTRY WASTES

The bacteria-dissolving enzyme of egg white—lysozyme—is being investigated at the Western Laboratory in the hope that it can be concentrated and purified for use in food preservation and as an antiseptic dressing in surgery. Perfection of methods of concentrating, purifying, and using lysozyme would lead to profitable utilization of large quantities of waste egg white adhering to and discarded with the shells at egg-processing plants or recovered and marketed at a very low price. Thus far it has been possible to concentrate about half of the total lysozyme of egg white in a fraction that is approximately six times as active as the original egg white per unit of solids.

Chemical researches on poultry feathers at the Western Laboratory have established beyond reasonable doubt that these and other cheap keratin-containing substances, which are extremely inert and insoluble in their native condition, have definite value as adhesives and sizing materials. When suitably processed and combined with certain resins, together with wood flour or similar filler, they can be molded into thermosetting articles having exceptional strength, stability, and water resistance. Laboratory findings have also shown that artificial fibers and film are among the more remote but nevertheless distinct possibilities.

PRESERVING VEGETABLES BY FREEZING

Investigations were started at the Western Laboratory to aid in the development of freezing preservation technology for vegetable products not previously preserved by freezing but preserved very largely by canning. The products under active investigation include cabbage, potatoes, beets, tomato juice, tomato pulp, tomato puree, and edible soybeans. Sufficient information was obtained to permit the formulation of specific recommendations for the freezing preservation of edible soybeans. In the case of the other items, storage experiments on the frozen products have not been in progress long enough to permit issuing recommendations.

At the request of the Agricultural Marketing Administration suggested grades for frozen cut corn, Lima beans, spinach, broccoli, cauliflower, and snap beans were written up and presented for consideration in the formulation of specifications and grades for frozen vegetables for civilian and military use. Experimental packs of frozen

vegetables were prepared to represent different varieties, degrees of maturity, and periods of delay in handling, for the purpose of working out refinements in the suggested grades for the frozen vegetables mentioned.

UTILIZING VEGETABLE WASTES

The juice of vegetable wastes, particularly asparagus butts, was found by the Western Laboratory to be an excellent medium for the growth of germicide-producing bacilli. Studies of the conditions under which the juice preparations may be used for growing the germicide-producing micro-organisms showed that greater yields of tyrothricin result from the use of this waste material than are obtained under the present conditions of commercial practice. A germicide that has not yet been reported in the literature, and which appears likely to be of interest in medicine, was obtained in the experiments. Asparagus juice was also found to be of potential value as a cheap culture medium for micro-organisms now used for producing certain enzymes for commercial purposes, and the necessary cultural conditions for producing enzymes in this way are being investigated.

Attention has been given to the technological problems of extracting, concentrating, and spray-drying vegetable juices for these and other uses.

In connection with a comprehensive survey by the Eastern Laboratory of the carotene and riboflavin contents of various vegetable materials and wastes, laboratory procedures were developed for the extraction of carotene and riboflavin from dried waste-vegetable materials. Results obtained so far indicate that the leafy portions of vegetables are the best sources of riboflavin as well as carotene.

USEFUL CHEMICALS FROM TOBACCO

Because of the anticipated increase in demand for nicotine for preparing insecticides and the antipellagra vitamin niacin (nicotinic acid) as a food supplement, laboratory and pilot-plant studies were conducted at the Eastern Laboratory to develop a simple and more direct method of obtaining nicotine from tobacco. In small pilot-plant laboratory equipment it was found that nicotine can be distilled directly from tobacco, which eliminates two steps in the established process and in addition yields concentrated solutions instead of dilute bulky ones. A special still of pilot-plant size was designed and constructed for this purpose and large-scale experimentation will now be undertaken.

Experimental work was conducted with a view to producing new fixed nicotine compounds and combinations for insecticidal use. About 40 double salts of nicotine, which are new to science, were prepared. In addition to nicotine they contain a heavy metal, such as copper, zinc, nickel, cadmium, or cobalt, combined with various acid radicals. These compounds are extremely fine, very insoluble powders suitable for either dusting or spraying. A number of these new nicotine compounds were tested for their insecticidal potency with promising results.

Laboratory studies on the catalytic oxidation of nicotine to nicotinic acid resulted in substantial yields. Liquid-phase oxidation with sulfuric acid and catalysts, such as mercuric sulfate and copper selenite,

resulted in yields as high as 50 percent of theoretical. Nicotinic acid was also obtained through vapor-phase catalytic oxidation of nicotine that results in the production of an intermediate compound from which the nicotinic acid is obtained by hydrolysis. A considerable number of catalytic agents were tested for both the liquid- and vapor-phase oxidations.

INDUSTRIAL PRODUCTS FROM MILK PROTEINS

Several economical precipitating agents were developed by the Eastern Laboratory for the recovery of proteins from cheese whey. Tests on the precipitated material indicated that it may have some value as an adhesive. The most efficient conditions for the use of such precipitating agents and the possibilities of utilizing coagulated cheese-whey protein material in the formation of plastics are being investigated. A wooden apparatus for the preparation of casein from skim milk on the farm was designed and constructed. The casein is precipitated from the skim milk in this apparatus with dilute sulfuric acid and after separation is air dried. The final product is lighter in color than any of the commercial acid caseins and is equal to the best of the commercial samples as regards solubility and adhesive strength.

At this time it is important to develop all possible satisfactory substitutes for wool. Artificial fiber of extruded casein or other proteins is one substitute that holds great promise. A simple laboratory spinning unit was designed and constructed, and considerable experimental work was carried on. The dry tensile strength of the fiber produced in this work was increased to 1 gram per denier or more. Although protein fiber, because of its heat-insulating properties, will have chief wartime use as a wool substitute, it is possible that a large increase in tensile strength might result in its use as a silk substitute. The work done thus far has indicated a number of promising points for attacking the problems of improving the properties of casein fiber.

INTERMEDIATES FOR SYNTHETIC RESINS AND RUBBER FROM LACTIC ACID

In a search for new industrial uses for lactic acid, a fermentation product of milk sugar and other carbohydrates, progress was made in the development of methods for converting the acid into acetyl and other derivatives and the pyrolytic conversion of these into synthetic resin and rubber intermediates such as methoxyethyl acrylate, ethoxyethyl acrylate, allyl acrylate, methallyl acrylate, methyl acrylate, and acrylonitrile. By a three-step method acrylonitrile can be made in high yield at a relatively low cost (about 20 cents per pound for materials). Either lactic acid or ethyl alcohol may be used as starting material.

An elastic, almost colorless, polymer of methyl acrylate was prepared which was soluble in the aromatic hydrocarbons, benzene, toluene, and xylene, but little affected by cymene, cyclohexene, paraffinic hydrocarbons, and mixtures of aromatic and paraffinic hydrocarbons.

The acetyl derivative of lactamide was prepared in high yield. This material should have utility as an intermediate and as a resin plasticizer. Methods were developed for making allyl and methallyl lactates, which were converted into the corresponding acetoxypropionates by acetylation. The pyrolysis of allyl acetoxypropionate and methallyl acetoxypropionate yields the corresponding acrylates.

These acrylic esters were found to give harder and less soluble resins than methyl acrylate.

INDUSTRIAL PRODUCTS FROM ANIMAL FATS

Experiments were performed at the Eastern Laboratory on the air oxidation of lard oils to prepare a modified oil having some of the properties of castor oil. Oleic acid, the chief unsaturated component of animal fats, was treated with air in the presence of various metallic salts in an attempt to find suitable catalysts and operating conditions which will yield useful oxidation products.

PREVENTING RANCIDITY IN ANIMAL FATS

Research was undertaken with a view to improving the stability of lard by the use of new synthetic antioxidants derived from l-ascorbic acid (vitamin C) and d-isoascorbic acid. The latter was included because it can probably be produced more cheaply than l-ascorbic acid. A method was developed by means of which one of the primary alcohol groups of the ascorbic acids can be esterified with a fatty acid to obtain a fat-soluble derivative in good yield without changing the structure to which the antioxidant and vitamin properties of the ascorbic acids are attributed. The 1-ascorbyl and d-isoascorbyl monoesters of lauric, myristic, palmitic, and stearic acids were prepared in pure form and characterized. As judged by recognized accelerated aging tests, these esters are effective antioxidants for lard oil and other oils. These new antioxidant materials, when used in conjunction with other known antioxidants, such as lecithin and α-tocopherol, exhibit pronounced synergistic effects, resulting in greatly enhanced stabilizing action on fatty materials. This discovery gives promise of broad industrial application of these agents for inhibiting rancidity. Aside from their potential value as antioxidants, the l-ascorbyl esters added to shortening may serve as a convenient means of incorporating vitamin C into special diets or rations such as may be required by our armed forces.

USES FOR POTATO STARCH AND DERIVATIVES

Work was done at the Eastern Laboratory on methods of preparing dextrin from potato starch. The effects of temperature, amount of moisture in the starch, amount of catalyst used, and other variables involved in the dextrinization of the starch were studied. Results indicated that dextrins can be made ranging from low solubility, high viscosity, and quick set to high solubility, low viscosity, and no gelling. If conditions of commercial dextrinization can be accurately controlled, dextrins with various desirable characteristics can be manufactured. Reports of tests made by commercial users of dextrins as adhesives indicate that those made from potato starch can be used with entire satisfaction to replace dextrin formerly made from imported cassava starch.

Primary and secondary starch esters which are soluble in organic solvents were prepared. Solutions of the starch acetate and acetobutyrate were prepared, applied successfully as coatings on metals and fibrous materials, and converted into flexible, transparent films. Supplementing cellulose esters and other plastic materials with starch

derivatives would alleviate the shortage of synthetic resins now used for adhesives, sizes, and lacquers.

DEVELOPING DOMESTIC TANNING MATERIALS

Tannin, which is derived from such agricultural products as barks, woods, leaves, fruits, nuts, and roots, is an essential constituent of heavy leathers, which include sole, strap, harness, and belting. Because of the many military and essential civilian needs for leather, it is imperative that adequate supplies of tanning materials be made available. Ordinarily about 50 percent of our tanning materials are imported, and because of the war a number of the foreign sources have been cut off. Increased production of domestic tanning materials is therefore essential to maintain adequate supplies.

In the Eastern Laboratory studies for the development of domestic tanning materials were continued in cooperation with the Bureau of Plant Industry and Soil Conservation Service. Observations on experimental canaigre plantings in Texas and New Mexico were continued. Data acquired concerning planting, cultivating, harvesting, yields, and tannin content of canaigre and sumac will be of immediate use if demands for rapid production of tanning materials of this type arise. Good canaigre yields appear to depend upon an adequate supply of moisture at the time of planting and during the growing season. In dry areas irrigation facilities should be available. Average tannin contents range from 20 to 25 percent, from which a satisfactory high-tannin, high-purity tanning extract can be prepared. On the basis of semicommercial tests, commercial drying of sumac appears feasible. By proper handling methods domestic sumac may be produced having qualities nearly equal to Sicilian sumac in both tannin content and color. The tannin content of Florida mangrove bark appears to be sufficiently high to justify a more thorough survey of available stands and a study of costs of gathering, transportation, and conversion into tanning extract. Tara has been found useful as a replacement material for Sicilian sumac and if it can be successfully grown in the United States would prove a valuable addition to domestic supplies.

DEVELOPING CHROME-SAVING TANNAGES

In connection with studies on conservation of chrome supplies by development of new tannages, studies of alum-retanned vegetable leathers were continued. Their superior resistance to acid deterioration by accelerated aging as compared to straight vegetable-tanned leathers was further confirmed. Tests indicate that they are superior to vegetable leathers and compare favorably with chrome-retanned vegetable leathers. In order to develop tannages utilizing domestic materials to replace imported tannins now unavailable, laboratory tanning tests were made using finely ground canaigre roots for direct tannage without prior conversion into an extract. This study is still in its initial stages and has been applied only in the retannage of leathers previously alum- or chrome-tanned.

CONSERVING DOMESTIC HIDES AND SKINS

Preliminary observations during 1941 on changes in salt-cured hides stored under aerobic and anaerobic conditions showed marked dif-

ferences in effects on the leather-making characteristics of the hides. More extensive studies to make practical application of these observations are in progress. Wild-boar skins from Brazil are potential sources of skins for leather and bristles for brushes. Since the cutting off of normal supplies from China, bristles are very scarce. Ordinary tannery unhairing processes utilize sulfides, and these destroy the valuable bristles. Pulling bristles without some loosening treatment damages the skins for use in leather. Experiments were therefore undertaken to develop procedures by which boar bristles can be removed undamaged without injury to the skins, thus conserving both of these valuable materials. The results of a 5-year study of cold storing of salted calfskins were published. These are the first data in which the effect of prolonged storage upon raw stock has been followed quantitatively in terms of finished leather. Matched calfskin sides were taken from cold storage at yearly intervals for 5 years and tanned. The resulting leathers showed no significant differences in yields, grades, selections, physical properties, and chemical composition.

NAVAL STORES INVESTIGATIONS

POTENTIAL SYNTHETIC-RUBBER INTERMEDIATES AND OTHER PRODUCTS FROM TURPENTINE

Investigations on turpentine derivatives during the past year yielded compounds that may be used with others in making synthetic rubber; they also yielded drying oil promoters, semidrying oils, and special synthetic resins. Since in rubber synthesis purity of the intermediate compounds constitutes an essential requirement, much emphasis has been placed on purification, not only of the intermediates themselves, but also of the materials from which they are made. With the aid of efficient fractionating columns, considerable quantities of highly purified α- and β-pinene, the initial materials, were isolated and with improved apparatus pyrolysates were produced from which the pure intermediates, myrcene and allo-ocimene, were prepared. Substantial samples of these materials were submitted to representative manufacturers for testing in rubber synthesis. Preliminary tests indicated that myrcene is very promising in rubber synthesis, especially for copolymerization. Derivatives of allo-ocimene may find use as rubber plasticizers and compounders. Unlike the well-known synthetic rubber intermediates, butadiene and styrene, myrcene has not yet been used in commercial rubber synthesis.

Allo-ocimene and α-pinene pyrolysates are the most active turpentine derivatives from the standpoint of film-forming or "drying" properties. The nonoily character of the pyrolysates, and the lack of similarity of physical properties to typical drying oils, place them in a somewhat unclassified and unique category—that of a combination thinner, drying oil, and promoter in which the drying-oil properties become manifest only under conditions of use. Thus α-pinene pyrolysate (allo-ocimene content about 40 percent) on evaporation in the air yields a residue as high as 20 percent (turpentine residue only 1 or 2 percent). Allo-ocimene itself absorbs as much as 35 percent of its own weight of oxygen in 24 hours. Results of preliminary experiments indicate that the oxygen absorption is strikingly catalytic

with an induction period of about 2 hours, generally followed by a period of relatively rapid absorption, after which the absorption continues more slowly for at least 100 hours. Allo-ocimene has been found to be a complex, separable into two forms. The two components (produced in unequal proportions) are about 2° C. apart in boiling point and 15° in freezing point. The lesser component is by far the more reactive, polymerizing to resin (with aluminum chloride catalyst) very rapidly. The existence of two allo-ocimenes was confirmed by Raman spectra.

SEPARATING TURPENTINE INTO COMPONENTS

The separation of turpentine into its components and the isolation and purification of derivatives are vitally dependent on vacuum fractionating equipment and technique. A new type of laboratory fractionating column has been developed, together with certain devices to control distillation rate, which is a critical factor in the efficiency of packed columns. Also, a safety system has been developed for continuous column operation to obviate shut-down at the end of a working day, permitting much more efficient operation. The new column is of a concentric-tube type, utilizing a new glass segmented-tube or rod packing spirally wound with glass thread. It has high efficiency (over 100 theoretical plates at optimum rate); permits high vapor velocity; has a low hold-up; and has a low pressure drop (i. e., low resistance to vapors). Low pressure drop is a vital factor in the fractionation of heat-sensitive terpenes since it permits operation at low still-pot temperatures, a necessary safeguard against decomposition. Although only laboratory-scale apparatus has been constructed thus far, consideration is being given to the translation of data and design from laboratory to pilot-plant and industrial scales. Application has been made for a public patent to cover an industrial column of this type, the packing being glass, ceramics, or metal.

GETTING STABLE RESINS FROM PINE GUM

In view of the war emergency, research on resin acids has been centered on the preparation from pine oleoresin of suitable supplements and substitutes for imported fossil gums and shellac, certain synthetic resins and plastics, and the widely used glyceryl ester of rosin commonly called ester gum. Attention was given to the practicability of isolating the stable constituents of pine gum for special uses. In connection with studies on polymerization of rosin as a means for improving stability, a viscous liquid product was obtained which has film-forming properties, and tests are in progress to determine its usefulness in protective coatings. Application for a public patent has been made.

ROSIN PRODUCTS TO REPLACE SCARCE ONES

The glyceryl ester of rosin is used in plastic compositions, in high-grade weather-resistant surface-coating compositions, and for certain war purposes. A laboratory study of esterification under various conditions and the properties of the ester gums obtained was completed and the results were published. The war needs for glycerin and other chemical materials used in synthetic resins has necessi-

tated the development of replacements from readily available materials. Improved limed rosins have been prepared which are relatively high in melting point (up to 160° C.). Melting points and other properties of these products are being studied to determine their suitability for special uses.

Work was initiated on the esterification of rosin with lactic acid, an abundantly available material, to obtain possible replacements for ester gum. Preliminary tests indicated that some reaction takes place between rosin and lactic acid or its salts, but the resulting products have not yet been fully identified. Promising resinous products were made by reacting fused rosin with butylene glycol under special conditions to prevent volatilization.

Naphthenate paint driers have been used in preference to resinate driers because of their greater stability in solution. The shortage of naphthenic acid has made it necessary to develop other suitable driers. Lead resinates having satisfactory stability and solubility have been prepared by the fusion method.

MILITARY USES FOR NAVAL STORES

Copper naphthenate has been accepted by the Corps of Engineers as a preservative for cotton and jute sandbag fabrics. Since increasing scarcity of naphthenic acid requires supplements and replacements, the copper compounds of rosin acids have been tried. Results of soil-burial and weathering tests conducted on cotton and jute fabrics treated with mineral-oil solutions of the copper salts of naphthenic acid, oleic acid, rosin, stabilized rosin, and tall oil or liquid rosin (containing about 50 percent of rosin acids) indicate that a portion of the naphthenic acid now used for treating fabrics can be replaced. Copper naphthenate gave better protection than the other individual preservatives. However, certain blends of copper naphthenate with other preservatives gave better protection than copper naphthenate alone. Copper resinate precipitated in the fabric gave much better protection against rotting than did copper resinate applied as a solution in mineral oil.

Crude sulfate wood turpentine, on burning in the standard testing apparatus, produced a blacker smoke than did the fuels ordinarily used for smoke screens and would therefore be useful only for special purposes.

Field tests were made to determine the value of rosin soaps and resin acids for modifying the properties of flame-thrower fuels. The results were not entirely satisfactory. Compositions containing naval-stores products were applied to the inner surface of tent fabrics to increase the reflection of heat from sunlight. Heat radiation from the treated surface was one-third less than from untreated fabric when the opposite surface was subjected to radiation simulating sunlight on a hot summer day.

In cooperation with the Navy Department, flameproofed and weather-resistant mats, having the appearance of grass, were developed for camouflage use. Other work of a confidential nature was also done for that Department.

INCREASING PRODUCTION OF NAVAL STORES

Direct assistance was given by field agents to 113 gum farmers and other naval-stores producers in production and related problems; 62 meetings were attended at which increased naval-stores production, conservation of metals, and other problems were discussed; 10 stills were inspected for reconditioning; assistance was given in the rebuilding of 10 stills and the resetting of 12 others; 3 fires were investigated; aid was given in the designing of 3 central processing plants; and assistance was given in the erection of 5. With representatives of the Bureau of Agricultural Economics a survey was made regarding gum marketing and processing. Many gum samples were collected in the field and brought to the station for distillation to obtain data for developing gum-grading methods and standards. During the year men from the Naval Stores Station made several field trips and held many conferences relative to the installation of the Bureau's gum-cleaning process, best temperatures in melters, steam pressures, and horsepower needed for cleaning equipment and steam stills, gum filters, sizes and gages of sheet metals needed for processing equipment, and the substitution of materials made necessary by the shortage of critical metals. At the station work was concentrated on the construction of pilot-plant equipment for acid washing of low-grade gum to remove the iron, development of a method for making rapid iron analyses on rosin, and the recovery of gum and turpentine from sediment by the use of filter aids.

STATISTICS TO GUIDE PRODUCTION AND USE OF NAVAL STORES

Timely and accurate data on production, stocks, and consumption of turpentine, rosin, and other naval-stores products are necessary for determining production goals and for allocation to war, industry, and lend-lease requirements. The regular semiannual and annual reports covering turpentine and rosin were published and distributed to the trade. At the request of the War Production Board and other war agencies for more nearly current information, statistical data on naval stores for the first quarter of the present naval-stores year were collected for exclusive use by these agencies.

WARTIME CHANGES IN MAKING, HANDLING, AND STORING NAVAL STORES

To conserve metal for the war effort, a method was developed for reconditioning used turpentine cups and an improved wooden vat was designed to facilitate cleaning the cups. Used lubricating oil cans were tried as substitutes for turpentine cups and much work was done on the introduction of glass turpentine cups and the development of gum-resistant paint for metal cups. Accelerated tests on containers for rosin and turpentine were carried out to find substitutes for the metals now used. Wooden barrels protected with preservatives, fiberboard drums, and black-iron drums with protective coatings were among the types of containers tested. Storage tests were conducted on turpentine in terneplate and glass containers to determine their suitability as substitutes for tin-plate containers. Work was done on the improvement of a previously designed jet condenser. This condenser requires little critical material as compared to the worm-type tur-

pentine condenser in general use. A trap for use on turpentine still-heads to stop particles of resin acid entrained with the vapors has been designed and is ready for testing.

AGRICULTURAL ENGINEERING INVESTIGATIONS

CONSERVING EXISTING FARM STRUCTURES

One of the principal objectives of the Bureau's Division of Farm Structures Research, since the United States became involved in the Second World War, has been to acquire and disseminate information that will help in conserving existing farm structures and make them serve for needs that might be met with new structures under ordinary circumstances. Studies which dealt particularly with the ways in which the planning, construction, and materials of farm houses affect the comfort of occupants were suspended for the duration of the war. Likewise, in the investigation of equipment and facilities for farmsteads, the studies that dealt with orchard heaters, wood-burning domestic heaters, and the conservation of fuel in domestic oil burners, which were practically completed except for some desirable refinements in equipment or practice, were also suspended.

Literature was prepared which gives suggestions on how to locate individual farm structures with respect to each other, so as to prevent the rapid spread of fire that might start in any one of them. This literature also calls attention to farm equipment suitable for fighting fires. No research was involved in these activities.

Information was furnished to farmers on how they can alter certain structures to adapt them to wartime needs, like farm storage of new or larger crops. It has become necessary to use available structures for storing larger crops of grain for which new storage structures cannot be provided because of the shortage of all commonly used building materials. Statements of the fundamental structural requirements of buildings for use as dairy barns, hog houses, and poultry houses have been prepared as a basis in converting buildings to other than their original uses. Suggestions have been made as to how structures can be insulated or tightened to require a minimum amount of heat, thus conserving short supplies of fuel. Suggestions were also made for repairing farm buildings with materials locally available.

FARM STRUCTURES FOR STORING CROPS

The plans for large expansion of the peanut crop to increase the supply of vegetable oil meant that additional storage facilities would be required. To aid in supplying them the Division of Farm Structures Research assisted the Office for Agricultural War Relations in examining plans submitted by various peanut growers. Several designs were made to eliminate most of the metal which would be required if the commercial plans were followed.

Because of the importance, under existing war conditions, of holding all food crops in sound condition for longer periods than usual, special attention was given to the potato-storage project which has been expanded to cover the particular needs in Colorado. The improved storage house recently developed by the Division, in which the principle of shell cooling is applied, apparently will prove successful in Nebraska and Colorado, as it did in Maine and Michigan. Efforts

were made to develop proper methods of shipping and handling washed seed stock so as to prevent bruising and sprouting.

The apple industry in the Wenatchee-Okanogan area of Washington has been handicapped by lack of facilities for properly cooling Delicious apples and suitable storages for holding them. Many of the special requirements for best storage results with this variety have been determined and are being provided in new storage houses for that area so that the apple crops may be held for longer periods. Application of this information will also improve the management of existing cold storages for apples.

Studies are being made at Ames, Iowa, and Urbana, Ill., to determine the crib characteristics most conducive to the drying of ear corn, the influence of various weather conditions on the rate of drying of ear corn in storage, and the fluctuations in moisture content of dried corn with changes in temperature, and to develop ventilated bins suitable for the storage of high-moisture shelled corn. The results of several years' work have shown that crib ventilators are not as effective as ordinarily supposed. The width of the crib is the most important structural factor as regards the rate of drying, although protection must be given to the upper walls to prevent snow from blowing in on top of the corn. Down-draft ventilation in circular bins, which was found most successful in drying wheat and grain sorghums, is being tried with ear corn.

Cooperative studies, supported by special research funds appropriated under the Bankhead-Jones Act, are in progress on the storage of wheat, corn, and grain sorghums on the farm. Farm storage will have to be provided for the bulk of the new grain crops. The metal bins previously designed in this work, which have proved very satisfactory, are no longer available and bins are being designed in which wood can be used economically. Since lumber is now a critical material, the Farm Structures Division is testing bins built of noncritical materials with the hope of finding a satisfactory type for farm use.

The Division has been actitvely engaged in designing and investigating bins of different types and materials so as to be able to recommend to the Commodity Credit Corporation types of bins that will provide safe storage for grains upon which they have made loans in connection with the Ever-Normal Granary program.

In addition to corn and wheat, other crops such as grain sorghums and soybeans must be stored in large quantities. Studies are therefore being made to determine what types of bins are suitable for storing these grains safely.

USING LESS CRITICAL MATERIALS IN FARM STRUCTURES

The Farm Structures Division has been very active in supplying information to the Office for Agricultural War Relations pertinent to establishing priorities for different critical materials for use in various types of agricultural structures. Estimates were made of the amounts of materials needed for barn and barnyard equipment and poultry-raising equipment, and of the metal required for farm buildings, fences, and miscellaneous equipment. Information has been disseminated on how farmers can use more masonry and other local materials to conserve metal and wood.

OBSCURING LIGHTED POULTRY HOUSES AND DAIRY BARNS

Several types of farm buildings have been studied with the view of determining the best method of concealing lights in them from the outside without shutting off ventilation. Where lights are used in poultry houses or dairy barns to increase production of eggs or permit milking, some means should be provided to prevent their serving as a beacon for possible air raiders. In devising such means it is necessary that sufficient ventilation be provided to keep the stock healthy.

EQUIPMENT FOR FIGHTING PLANT PESTS

In addition to expanding the investigations of dusting equipment and dusting materials, mentioned in the 1941 report, the Division of Farm Mechanical Equipment Research inaugurated a study of the effects of dust abrasion on commercial crop dusters and developed equipment for testing the abrasiveness of dusts. Damage to duster parts from abrasion has become a serious problem within the last few years, owing to the introduction of large high-velocity machines and the common use of new and highly abrasive dusts, and is of particular significance at this time because of limitations on the use of critical materials. These studies are the first step toward correcting this condition. Twenty-five diluents for insecticidal dusts, including talcs, gypsums, clays, phosphate rock, and lime, were tested. The results have been of value to manufacturers in attempting to reduce the abrasiveness of the diluent materials by changing milling methods.

A high-clearance, self-propelled sprayer, incorporating a sprayer unit, duster unit, and high-pressure atomizing unit to meet a wide variety of field conditions, was developed. It performed satisfactorily in field tests. When used to treat half of a commercial field of sweet corn badly infested with the European corn borer, the treated portion of the field yielded 632 percent more borer-free ears than did the nontreated portion.

MACHINERY FOR CONSERVING FERTILIZER

The demands for greater crop production in the face of dwindling fertilizer supplies make more necessary than ever the efficient use of available stocks of fertilizers. Increasing concentration of plant foods in fertilizers and the results of numerous experiments on the relation of fertilizer placement to crop yields have emphasized the need for specially designed fertilizer placement machinery to prevent waste. With the aid of such equipment fertilizing practices that insure maximum yields may be established. Last year four special machines of this kind were constructed in the Bureau shop; namely, a two-row planter with adjustable fertilizer placing device for use in initial investigations on vegetable crops (especially beans, beets, and spinach) in the Northwest; a planter equipped for deep placement of fertilizer for use particularly on cannery peas in Minnesota; a one-horse fertilizer distributor equipped with an accurately metering fertilizer hopper and soil tools for band placement of fertilizer—mainly for use in Michigan for side dressing crops; and a tractor carrying two accurately metering fertilizer hoppers and equipped with a two-way plow for deep fertilizer-placement studies in New York. The work incident to the general study included 35 fertilizer-placement machine experiments with 13 crops in 9 States.

MACHINES TO INCREASE PRODUCTION OR REDUCE COST OF CROPS

During the past year mechanical thinning of sugar beets has been done on a sufficiently large scale to be accepted by industry. This move was started by the Bureau of Agricultural Engineering in 1933 is just now being accepted because of the acute labor shortage. Results of experiments have shown that mechanical thinning requires less than half the usual labor. As a result of this work two types of beet harvesters have been developed and 15 harvesters of one type are to be put into the field this year. In field tests with a modified planter, using 2 to 3 pounds of segmented beet seed per acre, the stand compared favorably with that given by whole seed planted at the rate of 6 to 7 pounds per acre. This new technique of planting, using single-cell seed plates in the planter, gives promise of reducing planting costs by saving seed and cutting down the labor ordinarily required in thinning.

Curtailment of castor bean imports and urgent industrial needs for the oil gave rise to a plan for increasing domestic production of castor beans, which up to this time have been grown in only insignificant quantities. Accordingly attention was given to hulling requirements. An experimental cylinder-type huller was designed, after which five machines were built commercially to assist in hulling the 1942 crop. Some attention was also given to bean planters with the idea of minimizing damage in planting, since the seed is susceptible to skin damage which adversely affects its viability.

Increased peanut production to compensate for shortages in vegetable oils has likewise created a demand for special production machinery. Improvements were accordingly made in peanut hullers, and an experimental planter was developed. Since peanut harvesting entails a large amount of hand labor, the mechanization of this operation has been given special consideration. Experiments are being conducted with two types of peanut diggers. Different methods of handling the vines for curing and picking to minimize labor requirements have been considered. Attention has also been given to a sweep which will cut the roots just below the nuts, leaving the nitrogen-containing nodules in the ground.

Studies of corn-production machinery showed that with best adapted cultivating equipment weeds were kept under control by one cultivation with weeder and two with tractor-mounted cultivator. This practice effects a saving in labor and power over those normally consumed by Iowa farmers. Improvements were made in the experimental field-corn picker and alterations were made to adapt it for sweet-corn picking. An experimental sweep rake for use in haying-machinery studies was constructed and used to advantage in putting up a second cutting of alfalfa hay. Labor and machine studies were made with different tools, including stationary and pick-up hay balers, and fundamental studies were inaugurated to determine the optimum moisture content and bale density for safe storage of hay.

In the production of sweetpotatoes farmers reported savings as high as 50 percent in harvesting labor over local methods when using a rod-wing digger and an eight-unit bagging cart developed by Bureau engineers. Because of difficulties in getting rubber tires and in order to minimize the use of steel, a sled-type bagging unit, made almost

wholly of wood, was developed as a substitute for the wheel-supported one. Sweetpotato plantings for testing out experimental equipment were made on about 45 acres of bottomland. A one-mule, two-row planter for use without water, as well as a two-mule transplanter, have been developed. A commercial digger was altered to convey the sweetpotatoes to a bagging device after the dirt had been shaken off.

SPECIAL EQUIPMENT FOR MULCH CULTURE AND FOR LOW-INCOME FARMERS

New cultural techniques for the retention of moisture and prevention of erosion through residue-mulch farming have been tried out in several of the western and southern States. Crops planted in trash mulch on experimental fields near Tuskegee, Ala., were cultivated successfully with both sweeps and rotary hoe with no more labor required than when the trash is plowed under and the ordinary equipment is used. Based on present data secured in growing wheat, corn, grain sorghum, and potatoes, increased crop yields may be expected in this type of farming.

To bring the large number of one-mule farms of the South and elsewhere into greater production, special effort has been made to provide them with more adequate tools. Accordingly, a terracer with handles, a plow with legume-covering attachments, a stalk cutter to aid in boll-weevil control, a peanut planter, and two types of vetch planters were devised.

COLLABORATION IN NATIONAL PROGRAMS

In the program for conservation of existing farm machinery the Bureau has engaged in the preparation of articles on the care, repair, and operation of a number of farm machines and other equipment. This material has been distributed through State extension agencies as farm flashes and as mimeographed information sheets.

Considerable assistance has been given through committee assignments dealing with allocation of materials used in farm-machinery construction and rationing. Decreasing amounts of scarce materials and equipment allotted for civilian use make necessary more than ever their equitable distribution to maintain crop-production goals as high as possible.

GINNING COTTON FOR BEST FIBER QUALITY

The Cotton Ginning and Fiber Laboratory of the Department is operated jointly by this Bureau and the Agricultural Marketing Administration for research on mechanical processing of cotton for maximum retention of fiber quality. It is located advantageously at Stoneville, Miss., and extends its outlying tests to all parts of the Cotton Belt in cooperation with Department and State experiment stations, including the United States Cotton Experiment Station at Sacaton, Ariz.

During the fiscal year, 1,352 research tests were conducted on both saw and roller types of ginning apparatus. The results contributed to better knowledge of conditioning, storing, effect of mechanical picking, and the means for modernizing gins. From these tests came information in regard to improved methods of removing the ginning lint from roller gins to secure better preparation, which is now being put to practical use.

Dependable and complete surveys of gins typical of the principal regions were made to determine extent of improvements, adoption of better practices, and problems encountered during the year. The new surveys totaled 126 and resurveys of cooperating gins previously inspected, 644. Several gin appraisals were also made for government agencies.

Engineering improvements were achieved in ginning, drying, piping, fans, blowers, seed conveying, and seed separation. For example, seeds were blown 400 feet in a practical system that required only 4-inch pipe and low power. A simplified suction-blow seed separator and a pure-seed system of another type were also successfully developed. New instruments were devised for indicating moisture content in lint cotton. A new form of pneumatic seed-cotton distributor was achieved after 3 years of effort and prepared for final tests. This distributor has no moving parts; it is durable, cheap, and suitable for the majority of gins in the central and southeastern Cotton States. The engineering application of air-blast humidification to extra dry cotton increased bale weight by 5 pounds and restored the fibers to their original length, which had been shortened by excessive drying.

Because of the war needs for very long staple cottons, men and machinery were transported from Stoneville to Sacaton, Ariz., to make important experiments in roller-gin operation with such cottons. The tests showed that greater capacity and pneumatic lint-handling are both feasible. Shortages of walrus leather and critical metals make these developments significant in the production of very long staple cottons in greater quantity and of higher quality.

MAKING COTTON BALES BETTER AT GINS

The research on uniform packaging and pressing of cotton supported by special research funds appropriated under the Bankhead-Jones Act and conducted jointly by this Bureau and the Agricultural Marketing Administration at Stoneville, has shown that existing gin presses, in many instances, can be cheaply improved to produce 18-pound density instead of the present 13-pound density in gin bales. Also, as a result of this work the Laboratory can provide designs for new gin presses to produce bales of 24-pound or standard-compress density concurrently with ginning and at no increase in power requirements.

The results of an extensive series of cotton-pressing tests on several hundred bales of different weights, dimensions, and methods of covering, which have been under way for 2 years, have provided an extensive and useful fund of engineering and technological data. Good pumping combinations for hydraulic pressing have been determined from both engineering and technological viewpoints. These are being applied in supplementary tests and new studies, and include laboratory developments and improvements that the public may use freely. From the studies made thus far it appears that the most desirable package for improved cotton-gin practices is a 500-pound standard-density bale; that is, one containing 24 pounds of cotton per cubic foot. Overweight and irregular-shaped bales have given much trouble. Cotton bales made in narrow press boxes and pressed to the standard density of 24 pounds per cubic foot did not consume more energy than bales at the same density made in boxes of the usual width, but heavier ties

were necessary to hold such narrow bales. At farm gins such narrow bales might be produced with existing press pumps if the structural features of the press are adequate.

Intensive studies were made at various cotton compresses throughout the Cotton Belt upon many thousands of bales of cotton in order to determine the cause and remedy for compress cutting of bales, which in the past has resulted in rejection by the cotton buyers or a cut in price, which loss was passed back directly to the farmers. It is believed that this problem is about solved.

FLAX-PULLING AND -PROCESSING MACHINES

While new flax pullers in use in Oregon are superior in many respects to the old ones, the cost of pulling and the subsequent deseeding continues out of line with comparable operations on other crops. In an effort to reduce the cost of these operations a machine has been constructed for combining the pulling and deseeding. This machine is designed to pull the flax, deseed it, form a bundle and tie with two strings, thresh, and sack the seed. It was used in harvesting about 30 acres of flax during the 1942 season with encouraging results.

Deseeders of the Bureau's design were further improved by simplifying the mechanism which holds the combs in a vertical position in the revolving comb assembly. A tow cleaner which has great possibilities for solving the tow problem in Oregon was developed and put in operation. This machine apparently will produce commercially acceptable tow if the uncleaned tow is dry and relatively free from weeds. With the addition of a drier the machine should prove satisfactory for cleaning water-retted scutching tow under average Oregon conditions.

During the fiscal year plans were developed for flax mills in which the arrangement and design of buildings should permit more efficient operation. The deseeding and scutching operations are performed in separate buildings to minimize the dust and fire hazards. Elevators are provided for filling the sheds, and more retting capacity is provided than has been customary. Four of the five new mills constructed in Oregon used plans prepared by the Bureau as a basis for construction work.

EQUIPMENT FOR COOLING EGGS ON FARMS

Investigations in the development of economic uses for electricity in agriculture have been discontinued for the duration of the war, except for cooperative experiments at Virginia Polytechnic Institute and the University of Nebraska with electrical equipment, in comparison with other devices, for the cooling of eggs on farms and at receiving stations. Because of the importance of conserving eggs for food uses during the war emergency, three different methods of cooling eggs are being studied in an effort to determine which is most feasible for use on farms. The common belief that eggs should be cooled to 60° F. or lower as soon as possible after being laid and kept at that temperature in air containing 70 to 80 percent relative humidity has been justified experimentally. The low temperature retards fungus growth and prevents incubation, and the high humidity prevents evaporation of water from the contents of the egg and

accompanying enlargement of the air cell which lowers the candling grade. Some of the early findings from this research have already had practical application by producers and poultry produce handlers.

HEMP-PROCESSING MACHINES

In order to facilitate large-scale domestic production of hemp fiber, which will soon be needed as a supplement and possible substitute for Manila fiber, sisal, and jute now difficult or impossible to import because of the war, investigations were started on hemp-harvesting and -processing machinery in the latter part of the year. Hemp is being produced on a small scale in Kentucky and in the northern part of the Corn Belt. The different kinds of harvesting equipment used in these two sections of the country and the existing processing equipment in the five small hemp-processing plants now operating have been studied critically. As far as possible the most desirable features of the different plants were incorporated in plans and specifications for a pilot mill, which will later be revised as found necessary for new processing plants. Observations have also been made on soil conditions in hemp-growing localities, and on methods of seeding, harvesting, retting, and handling for use in training additional producers, as well as plant operators. It is expected that about 70 plants will be required to process the American hemp crop in 1943.

INFORMATION AND PUBLICATIONS

The Bureau published 1 Technical Bulletin, 4 Circulars, 3 Miscellaneous Publications, 2 Farmers' Bulletins, 6 articles in the Journal of Agricultural Research, 1 annual report, 54 mimeographed circulars, and 172 articles in outside journals and proceedings. The Bureau also furnished information on various phases of its research through the Press and Radio Services of the Department and made a number of displays at exhibits.

Twenty patents were issued to scientists and engineers of the Bureau during the year.

Lists of publications issued and patents granted during the fiscal year have been prepared in mimeographed form for use in answering inquiries concerning recent work of the Bureau.

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